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CORRECTIVE MEASURES STUDY REPORT COMBINED SOLID WASTE MANAGEMENT UNIT 87 (SWMU 87) ZONE E CNC CHARLESTON SC

8/28/2003

CH2M HILL

CORRECTIVE MEASURES STUDY REPORT

Combined SWMU 87, Zone E

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

CH2M-Jones

August 2003

Contract N62467-99-C-0960

From: <Gary.Foster@CH2M.com>
To: <CVernoy@ensafe.com>
Date: 5/6/2004 3:54:10 PM
Subject: Some site document updates at CNC

Here is a summary of the deliverables associated with the sites that we discussed today regarding the sediment results:
SWMU 5/18/605/621 - RFIRA/IMCR/CMSWP Issued May 2003; CMS Issued Dec 2003 - DHEC Approved LTM w/LUCs Jan 2004
SWMU 36/620 - RFIRA/IMCR Issued Feb 2003; CMS Issued Aug 2003 - DHEC Approved LUCs Sep 2003
SWMU 21/54 - RFIRA/IMCR/CMSWP Issued May 2003; CMS Issued Nov 2003 - Issued RtCs March 2004, Recommending MNA
The only active sites that I identified near the area of drydocks 1 & 2 that we discussed were
SWMU 87/172/564 - RFIRA/CMSWP Issued Nov 2001; CMS Issued Aug 2003 - EPA approved MNA w/LUCs in Sept 2003
SWMU 83/84/574 - RFIRA/CMSWP Issued Jul 2002; CMS Issued Jan 2003- EPA Approved LUCs Jan 2004

All of these documents along with any RtCs and revisions should be in the Navy's library. Await your email for drawings and will discuss with Dean the possibility of attending (or conferencing in) a meeting next week.

CC: <rob.harrell@navy.mil>, <Dean.Williamson@CH2M.com>

196

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CH2MHILL

August 28, 2003

Mr. David Scaturo
Division of Hazardous and Infectious Wastes
South Carolina Department of Health and
Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: Corrective Measures Study Report (Revision 0) – Combined SWMU 87, Zone E

Dear Mr. Scaturo:

Enclosed please find four copies of the Corrective Measures Study Report (Revision 0) for Combined SWMU 87 in Zone E of the Charleston Naval Complex (CNC). This report has been prepared pursuant to agreements by the CNC BRAC Cleanup Team for completing the RCRA Corrective Action process.

Please do not hesitate to contact me at 352/335-5877, extension 2280, if you have any questions or comments.

Sincerely,

CH2M HILL

Dean Williamson

Dean Williamson, P.E.

cc: Tim Frederick/Gannett-Fleming, Inc., w/att
Dann Spariosu/USEPA, w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

CORRECTIVE MEASURES STUDY REPORT

Combined SWMU 87, Zone E

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

PREPARED BY
CH2M-Jones

August 2003

Revision 0
Contract N62467-99-C-0960
158814.ZE.EX.21

Certification Page for Corrective Measures Study Report (Revision 0) — SWMU 87, Zone E

I, Dean Williamson, certify that this report has been prepared under my direct supervision. The data and information are, to the best of my knowledge, accurate and correct, and the report has been prepared in accordance with current standards of practice for engineering.

South Carolina

P.E. No. 21428

Dean Williamson

Dean Williamson, P.E.

8/26/2003

Date

Contents

Contents, Continued

Contents, Continued

Acronyms and Abbreviations

1,2-DCE	1,2-dichloroethene
AOC	area of concern
BRAC	Base Realignment and Closure Act
CA	corrective action
CMS	corrective measures study
CNC	Charleston Naval Complex
COC	chemical of concern
COPC	chemical of potential concern
CSI	confirmatory sampling investigation
CVOC	chlorinated volatile organic compound
DO	dissolved oxygen
DPT	direct-push technology
EBST	Environmental Baseline Survey for Transfer
EnSafe	EnSafe Inc.
EPA	U.S. Environmental Protection Agency
ft bls	feet below land surface
ft msl	feet above mean sea level
gpm	gallon per minute
HI	hazard index
ILCR	Incremental Lifetime Cancer Risk
μg/L	microgram per liter
LUC	land use control
LUCMP	land use control management plan
MCL	maximum contaminant level
MCS	media cleanup standard
mg/kg	milligram per kilogram

Acronyms and Abbreviations, Continued

MNA	monitored natural attenuation
NAVBASE	Naval Base
ORC	oxygen release compound
ORP	oxidation reduction potential
OSWER	Office of Solid Waste and Emergency Response
OWS	oil/water separator
PCE	tetrachloroethene
RAO	remedial action objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RGO	remedial goal option
SCDHEC	South Carolina Department of Health and Environmental Control
SSL	soil screening level
SWMU	solid waste management unit
TCE	trichloroethene

Section 1.0

1.0 Introduction

In 1993, Naval Base (NAVBASE) Charleston was added to the list of bases scheduled for closure as part of the Defense Base Realignment and Closure Act (BRAC), which regulates closure and transition of property to the community. The Charleston Naval Complex (CNC) was formed as a result of the dis-establishment of the Charleston Naval Shipyard and NAVBASE on April 1, 1996.

Corrective Action (CA) activities are being conducted under the Resource Conservation and Recovery Act (RCRA), with the South Carolina Department of Health and Environmental Control (SCDHEC) as the lead agency for CA activities at the CNC. All RCRA CA activities are performed in accordance with the Final Permit (Permit No. SC0 170 022 560). In April 2000, CH2M-Jones was awarded a contract to provide environmental investigation and remediation services at the CNC.

A RCRA Facility Investigation (RFI) Report Addendum and Corrective Measures Study (CMS) Work Plan were prepared for Solid Waste Management Unit (SWMU) 87 and 172, and Area of Concern (AOC) 564 in Zone E of CNC (CH2M-Jones, 2003). These sites are located at the intersection of Fourth Street and Avenue A South, and they were investigated together because of their close proximity to each other. These sites will be collectively referred to as Combined SWMU 87 in this CMS report. The location of this combined site in Zone E is shown in Figure 1-1.

The RFI Report Addendum and CMS Work Plan presented the remedial action objectives (RAOs) and media cleanup standards (MCSs) proposed for Combined SWMU 87, and it was approved by the U.S. Environmental Protection Agency (EPA) Region IV on behalf of SCDHEC in April 2003. This CMS report has been prepared by CH2M-Jones to complete the next stage of the CA process for Combined SWMU 87.

1.1 Corrective Measures Study Report Purpose and Scope

This CMS report evaluates corrective measure alternatives for chlorinated volatile organic compound (CVOC)-contaminated groundwater at Combined SWMU 87. Figure 1-1 illustrates the location of Combined SWMU 87 within Zone E. Figure 1-2 is an aerial photograph showing the layout of Combined SWMU 87.

This CMS report consists of: 1) the identification of a set of corrective measure alternatives that are considered to be technically appropriate for addressing CVOC-contaminated groundwater; 2) an evaluation of the alternatives using standard criteria from EPA RCRA guidance; and 3) the selection of a recommended (preferred) corrective measure alternative for the site.

1.2 Background Information

This section of the CMS report presents background information on the facility, site history, and a summary of the nature and extent of the chemicals of concern (COCs) at the site. This information is essential to the understanding of the remedial goal options (RGOs), MCSs, and ultimately the evaluation of corrective measure alternatives for Combined SWMU 87. Additional information on the site and hydrogeology in the Zone E area of the CNC is provided in the *Zone E RFI Report, Revision 0* (EnSafe Inc. [EnSafe], 1997).

1.2.1 Facility Description and Site History

SWMU 87

SWMU 87 is a former less-than-90-day accumulation area that was once part of the Charleston Naval Shipyard hazardous waste management system. Located north of Building 80, the unit is a metal building with an asphalt foundation. Wastes were accumulated in closed, palletized 55-gallon drums and palletized plastic bags. The accumulation area was taken out of service in March 1994 and is currently a paved area.

SWMU 172

SWMU 172 consists of a former steam cleaning area north of Building 80. Steam cleaning was performed on various types of equipment, including small engines, generators, and construction equipment. The unit consisted of a concrete-paved area designed with curbing and sloping surfaces to drain liquids into two storm drains located between the concrete-paved area and Building 80, on the south side of the steam-cleaning area. This unit did not have an enclosure or a roof. Currently, no steam-cleaning operations exist at SWMU 172 and the paved area is being used to store equipment.

AOC 564

AOC 564 consisted of a 300-gallon oil/water separator (OWS) north of Building 80. Wastewater from machining and parts-cleaning in Building 80 drained onto a sloped asphalt ramp, which fed into an exterior drain connected to the OWS. At the time of the RFI, the OWS had been in operation for more than 25 years. Based on information from a visual site inspection conducted by CH2M-Jones as part of the Environmental Baseline Survey for Transfer (EBST) during April 2001, it appears that this OWS no longer exists.

A review of historical drawings for this site shows that railroad lines have been located north of the site since 1909. Currently, railroad lines still exist north and east of the site.

Materials of concern indicated in the *Final Zone E RFI Work Plan* (EnSafe/Allen & Hoshall, 1995) at Combined SWMU 87 were paint, mercury, anti-freeze, and petroleum hydrocarbons. Materials of concern identified for SWMU 172 and AOC 564 were petroleum hydrocarbons. This area of Zone E is zoned M2 (marine industrial). The CNC RCRA Permit identified Combined SWMU 87 as requiring confirmatory sampling investigation (CSI).

The RFI activities initially conducted by the Navy/EnSafe team were described in the *Zone E RFI Report, Revision 0* (EnSafe, 1997). Regulatory review was conducted on this document and draft responses to the comments from SCDHEC were prepared by the Navy/EnSafe team. These comments and responses are included in Appendix A of the RFI Report Addendum.

1.2.2 COC Summary

Soils

Based on the chemical of potential concern (COPC) review conducted in the Combined SWMU 87 RFI Report Addendum, arsenic and dieldrin in surface soils have been retained as COCs for the unrestricted land use scenario. Arsenic was retained as a surface soil COC for the unrestricted land use scenario due to potential human health exposure concerns. Dieldrin was retained as surface soil COC for the unpaved land use scenario due to potential leaching to groundwater concerns.

No surface soil COCs were identified for the industrial land use scenario.

No COCs were identified for subsurface soils at Combined SWMU 87.

Groundwater

1,2-dichloroethene (1,2-DCE) has been retained as a shallow groundwater COC due to the potential for its biodegradation into vinyl chloride, which has a lower maximum contaminant level (MCL) than 1,2-DCE.

Low-level concentrations of chlorobenzene and vinyl chloride have been detected in shallow groundwater above their respective MCLs, so they have also been retained as shallow groundwater COCs.

Low-level detections of tetrachloroethene (PCE) and trichloroethene (TCE), slightly above their respective MCLs, also occurred in several direct-push technology (DPT) groundwater samples that were collected at this site as part of the Zone L sanitary and storm sewer investigations; therefore, PCE and TCE are identified as COCs.

1.3 Summary of Groundwater Conditions

1.3.1 Summary of Hydrogeologic Setting at Combined SWMU 87

Combined SWMU 87 is located in the north-central portion of Zone E at the CNC, where the surface topography is relatively flat, with elevations ranging between approximately 12 feet above mean sea level (ft msl) to approximately 6 ft msl near the Cooper River waterfront. Because the area is highly industrialized, surface water runoff is largely controlled by a system of stormwater sewers that discharge to the Cooper River.

Surface Geology

Due to the extensive surface soil disturbance at CNC during the history of its operations, the soils from land surface to depths of approximately 6 feet are typically a mixture of artificial fill and native sediments. The extent of fill material present varies extensively, but in the vicinity of Combined SWMU 87, undifferentiated clay, sand, gravel, dredged material, and construction debris may be present at or near the land surface. In undisturbed areas, surface deposits consist of Quaternary age (Holocene epoch to recent) fine-grained sands and clays typical of a coastal plain environment, repeatedly reworked by marine and river water erosion prior to development by man.

Subsurface Geology

The Zone E RFI report included the installation of soil borings and more than 185 monitoring wells, from which geologic information was collected to develop geologic cross sections. The data indicate that Quaternary (Pleistocene to Holocene) and Tertiary age unconsolidated sediments were encountered in the subsurface. The lowermost unit encountered is the Tertiary age Ashley Formation member of the Mid-Tertiary age Cooper

Group. Overlying the Ashley Formation are younger upper Tertiary and Quaternary age deposits, which are in turn overlain by the Holocene to recent surface soils.

The Ashley Formation occurs at depths of approximately 16 to 43 feet below land surface (ft bls), except in northern Zone E, where it dips downward to the north, and was not encountered to depths of 75 ft msl, probably due to secondary erosion. In the remainder of Zone E, the top of the Ashley Formation is gently rolling and slopes gently downward to the east toward the Cooper River, with measured thickness approaching 40 feet. The Ashley Formation is comprised of brown to olive marine silts with varying amounts of clay, phosphatic sand and microfossils. The Ashley consistency is generally dense to stiff and plastic, with low vertical permeability.

In most areas of Zone E, the Ashley Formation is unconformably overlain by marine lagoon deposits of the Marks Head Formation, consisting of undifferentiated Tertiary age silts, clays and phosphatic sands of 2 to 15 feet in thickness.

The overlying Quaternary age deposits are back barrier and near shore shelf deposits from various past marine transgressions, with subsequent reworking erosion and redeposition. The result is a sequence approximately 15 to 85 feet thick at the CNC and comprised mainly of Pleistocene age Wando Formation sands, silts, and clays, with varying amounts of organic matter including peat.

At Combined SWMU 87, the Ashley Formation occurs at a depth of approximately 30 ft bls, based upon a boring completed during the installation of well E172GW02D. The Ashley Formation at Combined SWMU 87 is overlain by approximately 10 feet of undifferentiated Upper Tertiary age silt, then by approximately 12 feet of silty to sandy clay and finally by about 5 feet of fill to the land surface.

The COC contamination at Combined SWMU 87 has been found to be located primarily within the shallow aquifer clayey units, ranging from approximately 8 to 20 ft bls.

Hydrogeology

The shallow aquifer system at Combined SWMU 87 is an unconfined water table aquifer occurring within the Quaternary sediments. The underlying low-permeability Ashley Formation member acts as an aquitard for the shallow aquifer system and as a confining unit for deeper geologic units. The Cooper River acts as a regional discharge boundary for the aquifer to the east. The average saturated aquifer thickness in the Combined SWMU 87 area based on monitoring well water level data is approximately 20 feet.

Regionally in Zone E, the shallow groundwater flow direction is east, toward the Cooper River. Because a significant portion of Zone E is along the riverfront, the Cooper River is a major discharge boundary for the shallow aquifer system. However, because of extensive subsurface disturbances, presence of underground utility lines and subsurface heterogeneities, the local groundwater flow direction at any specific site may vary significantly from the regional flow direction.

Locally, at Combined SWMU 87, groundwater flow is generally northward, as indicated in potentiometric surface map (see Appendix A of this report). Section 2.2 of the *Zone E RFI Report, Revision 0* (EnSafe, 1997) indicates that significant tidal influence on groundwater elevations, and several positive and negative shallow groundwater elevation anomalies were observed in portions of Zone E during the RFI.

1.3.2 COC Distribution in Groundwater

COC exceedances of drinking water MCLS have been detected in a single shallow monitoring well at Combined SWMU 87 (E172GW001). COCs have been detected in a deeper monitoring well at the site but not at concentrations above MCLs. The overall extent of groundwater contamination is limited and the maximum COC concentrations are relatively low.

Figure 1-4 shows groundwater COC concentrations detected in monitoring wells at Combined SWMU 87. Of the groundwater COCs, chlorobenzene has been detected at the greatest frequency and at the greatest concentrations at the site, primarily in well E172GW001. It can be seen in Figure 1-4 that chlorobenzene concentrations exceeded its drinking water MCL of 100 microgram per liter (μg/L) on several occasions during the late 1990s but was well below the MCL during the last sampling event in 1998 (72 μg/L) and the most recent sampling event (January 2002), at a concentration of only 12.7 μg/L. In addition, chlorobenzene has not been detected at downgradient monitoring well locations, indicating that it is degrading as it migrates and is not impacting downgradient groundwater quality.

PCE, TCE, and cis-1,2-DCE have been detected only at relatively low (below 10 μg/L) concentrations in monitoring wells at the site, most frequently at concentrations below their respective MCLs. No COC detections above MCLs have been detected in monitoring wells downgradient of well E172GW001.

Figure 1-5 shows groundwater COC concentrations detected at DPT sampling locations at the site. No groundwater COCs have been detected in DPT samples collected downgradient (northward) of DPT sample E172GP001, indicating that little to no plume migration is occurring and that the plume is degrading as it migrates.

1.4 Overall Approach for Selecting Candidate Corrective Measure Alternatives for Combined SWMU 87

Because of the small size of Combined SWMU 87 and the relatively low levels of contamination in surface soil and groundwater, the list of practicable remedial alternatives for this site are limited.

Because all of Zone E will undergo Land Use Controls (LUCs) and the exceedances of screening criteria for arsenic and dieldrin in surface soil are isolated, LUCs will be considered as a presumptive remedy for surface soils. LUCs will preclude the property from being used for residential use as well as requiring that existing pavement cover at the site be maintained.

Two presumptive remedies will be considered for the groundwater COCs in the CMS:

- Monitored natural attenuation (MNA), and
- In situ treatment of CVOCs.

1.5 Report Organization

This CMS report consists of the following sections, including this introductory section:

1.0 Introduction — Presents the purpose of and background information relating to this CMS report.

2.0 Remedial Goal Objectives and Evaluation Criteria— Defines the RGOs for Combined SWMU 87, in addition to the criteria used in evaluating the corrective measure alternatives for the site.

3.0 Description of Candidate Corrective Measure Alternatives — Describes each of the candidate corrective measure alternatives for addressing CVOCs in groundwater and the LUC presumptive remedy for arsenic and dieldrin in surface soils.

4.0 Evaluation and Comparison of Corrective Measure Alternatives — Evaluates each alternative relative to standard criteria, then compares the alternatives and the degree to which they meet or achieve the evaluation criteria.

5.0 Recommended Corrective Measure Alternative — Describes the preferred corrective measure alternative to achieve the MCS and RGOs for CVOCs in groundwater based on a comparison of the alternatives.

6.0 References — Lists the references used in this document.

Appendix A contains a potentiometric surface map.

Appendix B contains cost estimates developed for the proposed corrective measure alternatives.

All tables and figures appear at the end of their respective sections.

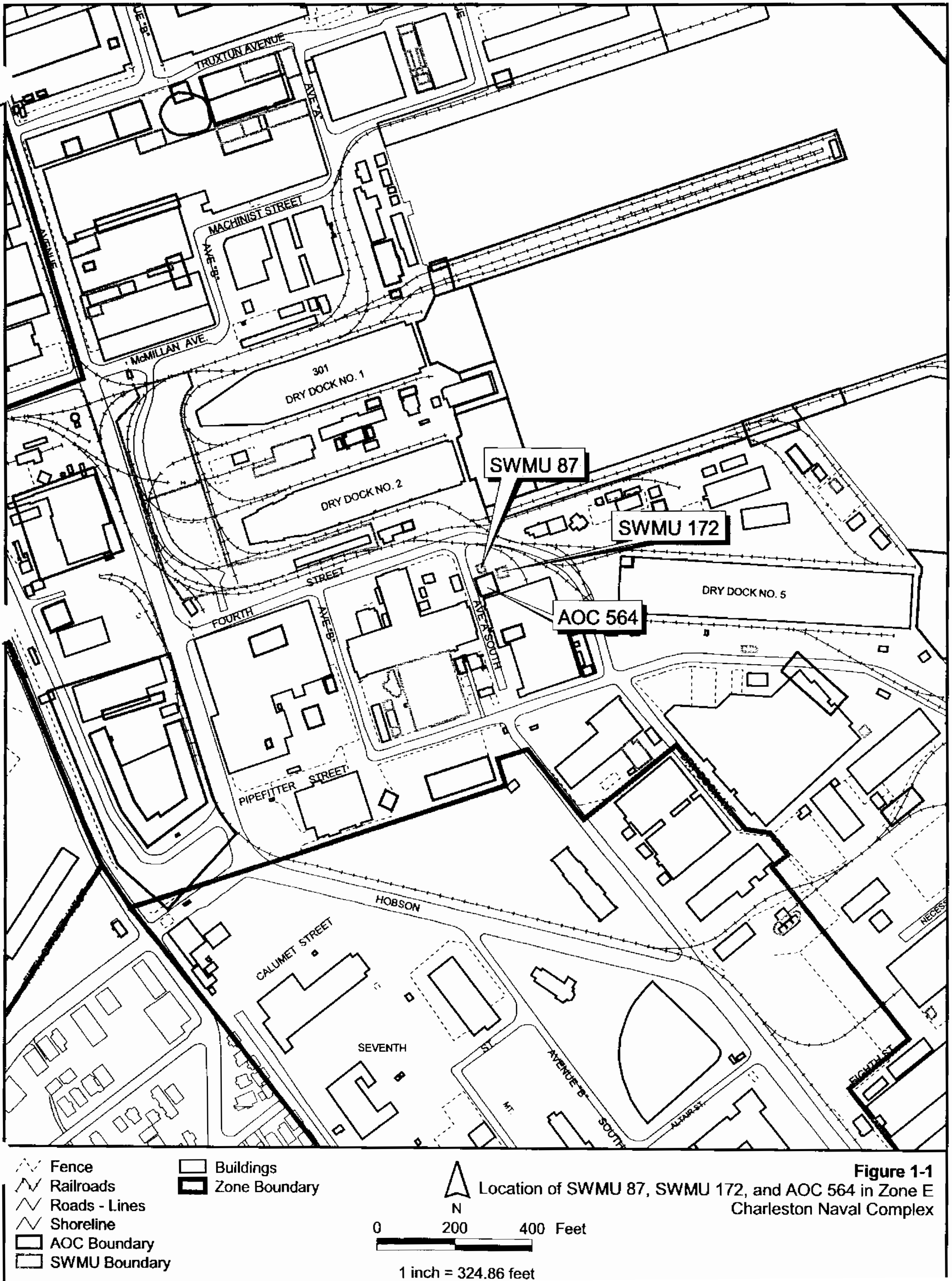
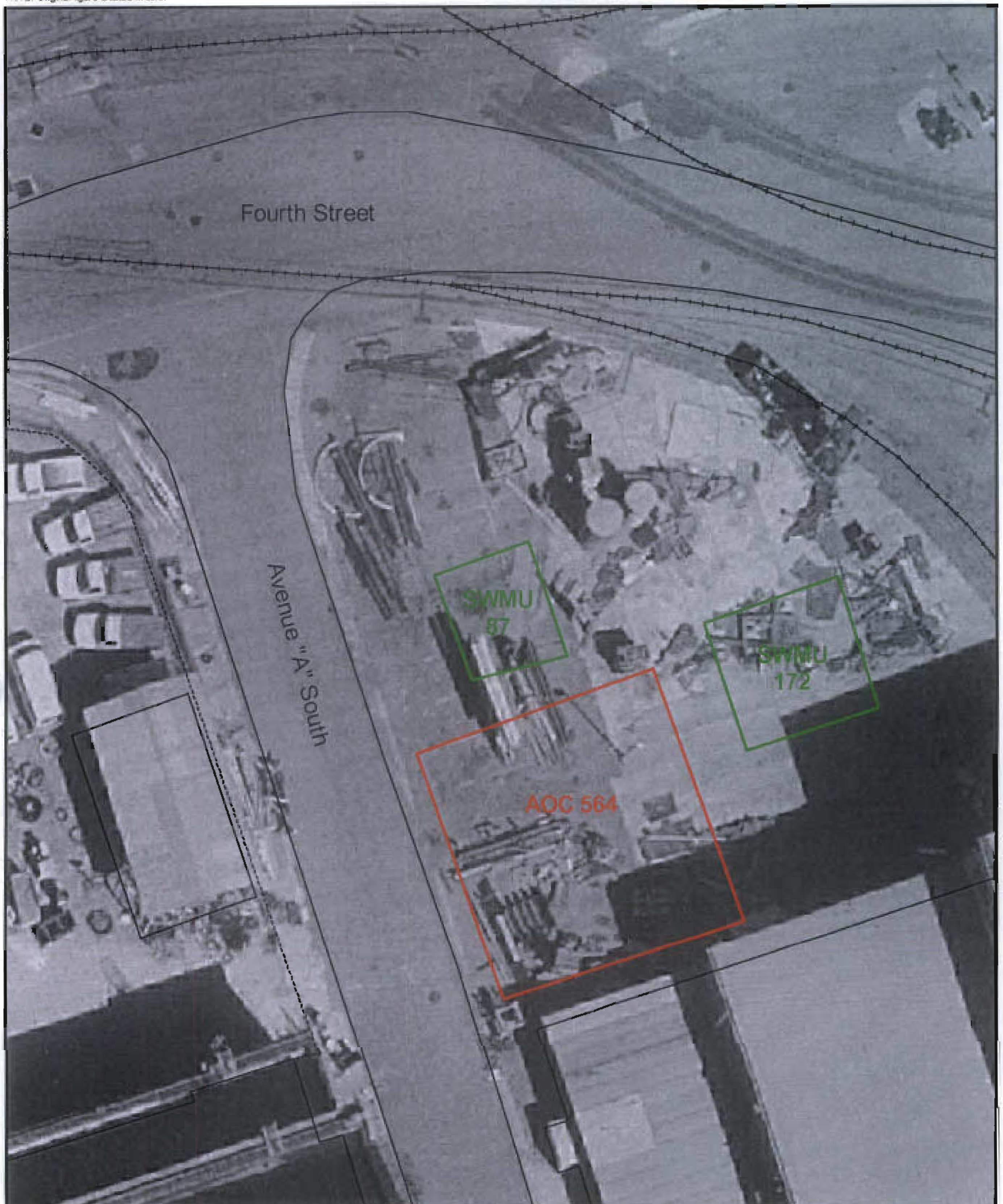


Figure 1-1
Location of SWMU 87, SWMU 172, and AOC 564 in Zone E
Charleston Naval Complex

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color



Fence
Railroads
Roads
AOC Boundary
SWMU Boundary
Buildings

N

0 20 40 Feet

1 inch = 25 feet

Figure 1-2
Aerial View
Combined SWMU 87, Zone E
Charleston Naval Complex

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File Path: c:\18gis\projects\usna_sl\swmu_87\apr\swmu87.apr, Date: 15 Jul 2003 8:11, User: NMOUDRY, Figure 1-2 Arial View

NOTE: Original figure created in color

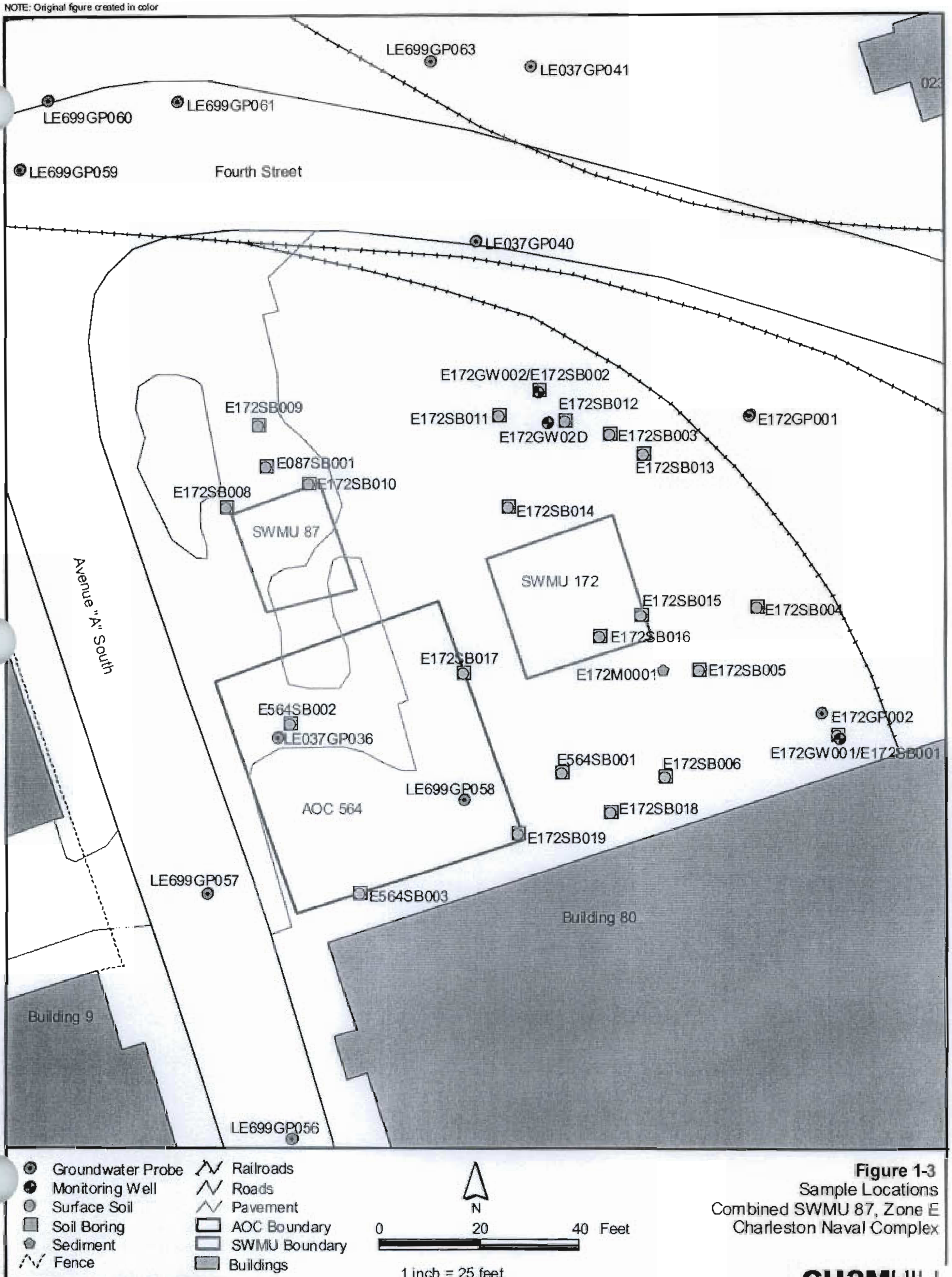

Figure 1-3
Sample Locations
Combined SWMU 87, Zone E
Charleston Naval Complex

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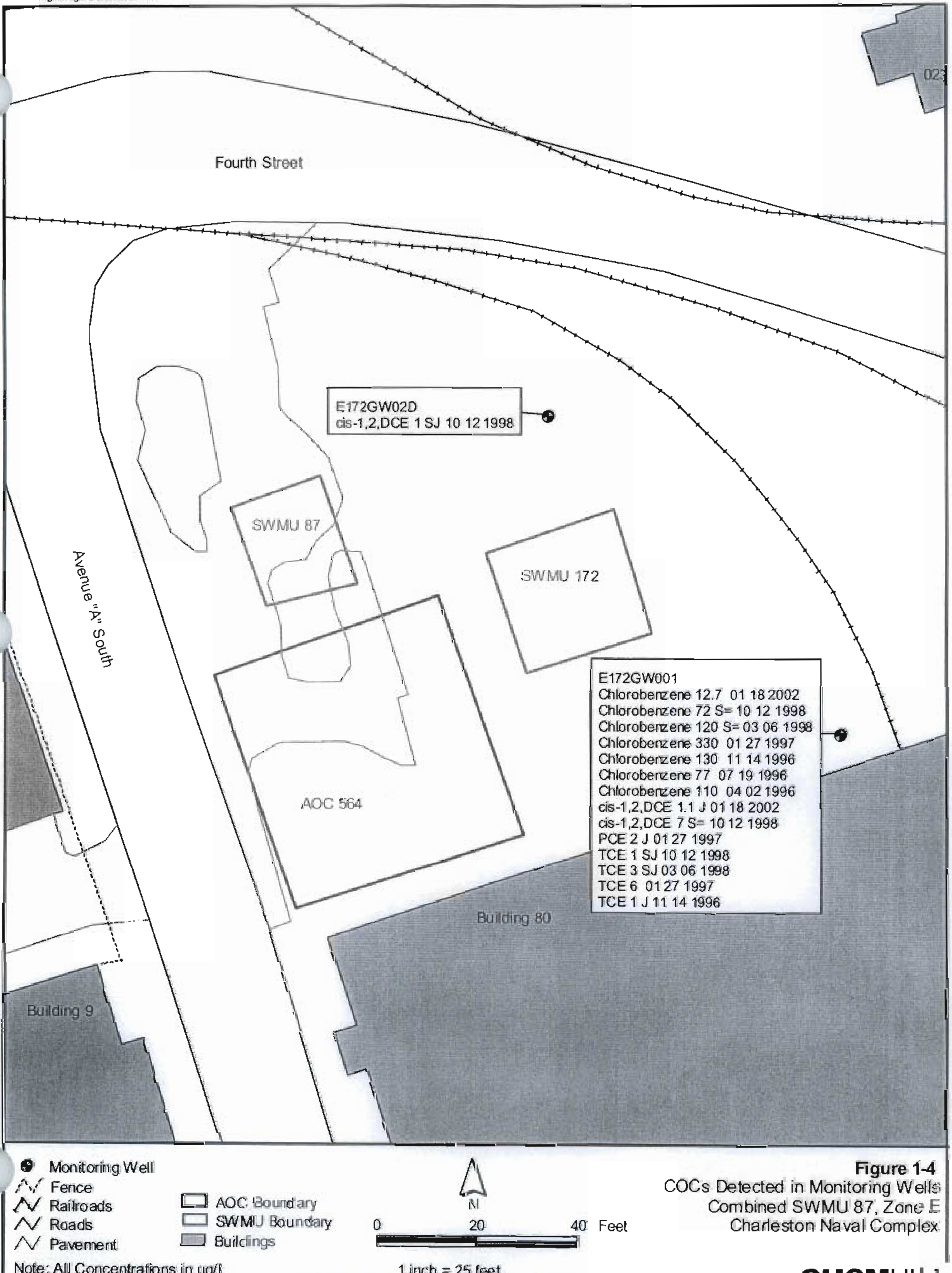
File Path: C:\18gis\Projects\Zone_E\swmu_87\apr\swmu87.apr, Date: 17 Jul 2003 7:18, User: NMOUDRY, Figure 2-1 Sample Locations

NOTE: Original figure created in color



Note: All Concentrations in ug/L

Figure 1-4
COCs Detected in Monitoring Wells
Combined SWMU 87, Zone E
Charleston Naval Complex

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File Path: C:\18gis\Projects\Zone E\swmu_87\apr\swmu87.apr, Date: 14 Aug 2003 8:05, User: NMCUDRY, Figure 1-4 GW COPC

NOTE: Original figure created in color

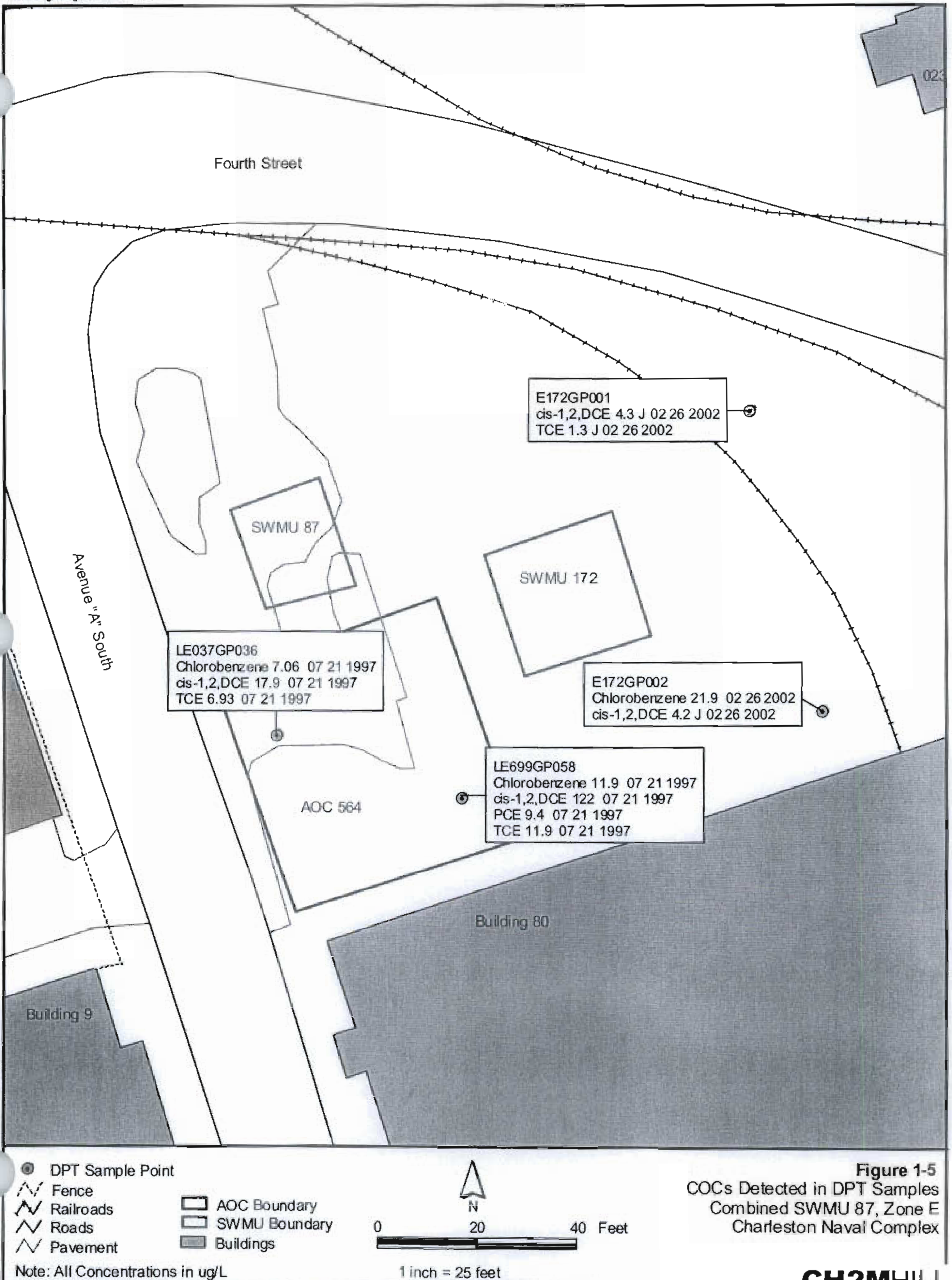

Figure 1-5
COCs Detected in DPT Samples
Combined SWMU 87, Zone E
Charleston Naval Complex

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Section 2.0

2.0 Remedial Goal Objectives and Evaluation Criteria

2.1 Remedial Action Objectives

RAOs are medium-specific goals that protect human health and the environment by preventing or reducing exposures under current and future land use conditions. The RAOs identified for the surface soil and groundwater at Combined SWMU 87 are being chosen to prevent ingestion of surface soil and groundwater containing COCs at unacceptable levels. All of Zone E is expected to undergo LUCs, and such LUCs will also be applicable for surface soils at this site.

2.2 Media Cleanup Standards

Throughout the process of remediating a hazardous waste site, a risk manager uses a progression of increasingly acceptable site-specific media levels in considering remedial alternatives. Under the RCRA program, RGOs and MCSs are developed at the end of the risk assessment in the RFI/Remedial Investigation (RI) programs, before completion of the CMS.

RGOs can be based on a variety of criteria, such as specific incremental lifetime cancer risk (ILCR) levels (e.g., 1E-04, 1E-05, or 1E-06), HI levels (e.g., 0.1, 1.0, 3.0), or site background concentrations. For a particular RGO, specific MCSs can be determined as target concentration values. Achieving these MCSs is accepted as demonstrating that RGOs and RAOs have been achieved. Achieving these goals should promote the protection of human health and the environment, while achieving compliance with applicable state and federal standards.

The exposure media of concern for Combined SWMU 87 are surface soil impacted by arsenic and dieldrin, and groundwater impacted by low-levels of 1,2-DCE, chlorobenzene, PCE, TCE and vinyl chloride. Because this site is located within a highly developed area of the CNC and there are no surface water bodies in the immediate vicinity of the site, ecological exposures were not considered applicable for evaluation.

For the chemicals identified as COCs in soil and shallow groundwater, the following MCSs are proposed:

COC	Target MCS
Soil	
Arsenic	20 milligram per kilogram (mg/kg) – EPA Region IV acceptable level for unrestricted land use, where arsenic background concentrations exceed RBCs.
Dieldrin	Site-specific soil screening level (SSL) for the unpaved scenario (0.012 mg/kg).
Groundwater	
PCE	MCL for PCE - 5 μg/L
TCE	MCL for TCE - 5 μg/L
1,2-DCE	MCL for 1,2-DCE of 70 μg/L
Chlorobenzene	MCL for chlorobenzene of 100 μg/L
Vinyl Chloride	MCL for vinyl chloride of 2 μg/L

2.3 Evaluation Criteria

According to the EPA RCRA CA guidance, corrective measure alternatives should be evaluated using the following five criteria:

1. Protection of human health and the environment.
2. Attainment of MCSs.
3. The control of the source of releases to minimize future releases that may pose a threat to human health and the environment.
4. Compliance with applicable standards for the management of wastes generated by remedial activities.
5. Other factors, including (a) long-term reliability and effectiveness; (b) reduction in toxicity, mobility, or volume of wastes; (c) short-term effectiveness; (d) implementability; and (e) cost.

Each of these criteria is defined in more detail below:

1. **Protection of human health and the environment.** The alternatives will be evaluated on the basis of their ability to protect human health and the environment. The ability of an alternative to achieve this criterion may or may not be independent of its ability to achieve the other criteria. For example, an alternative may be protective of human

health, but may not be able to attain the MCSs if the MCSs were not developed based on human health protection factors.

2. **Attainment of MCSs.** The alternatives will be evaluated on the basis of their ability to achieve the MCS defined in this CMS. Another aspect of this criterion is the time frame required to achieve the MCS. Estimates of the time frame for the alternatives to achieve RGOs will be provided.

3. **The control the source of releases.** This criterion deals with the control of releases of contamination from the source (the area in which the contamination originated) and the prevention of future migration to uncontaminated areas.

4. **Compliance with applicable standards for management of wastes.** This criterion deals with the management of wastes derived from implementing the alternatives (i.e., treatment or disposal of zinc-contaminated residuals from groundwater treatment processes). Corrective measure alternatives will be designed to comply with all standards for management of wastes. Consequently, this criterion will not be explicitly included in the detailed evaluation presented in the CMS, but such compliance would be incorporated into the cost estimates for which this criterion is relevant.

5. **Other factors.** Five other factors are to be considered if an alternative is found to meet the four criteria described above. These other factors are as follows:

   a. Long-term reliability and effectiveness

   Corrective measure alternatives will be evaluated on the basis of their reliability, and the potential impact should the alternative fail. In other words, a qualitative assessment will be made as to the chance of the alternative's failing and the consequences of that failure.

   b. Reduction in the toxicity, mobility, or volume of wastes

   Alternatives with technologies that reduce the toxicity, mobility, or volume of the contamination will be generally favored over those that do not. Consequently, a qualitative assessment of this factor will be performed for each alternative.

   c. Short-term effectiveness

   Alternatives will be evaluated on the basis of the risk they create during the implementation of the remedy. Factors that may be considered include fire, explosion, and exposure of workers to hazardous substances.

   d. Implementability

The alternatives will be evaluated for their implementability by considering any difficulties associated with conducting the alternatives (such as the construction disturbances they may create), operation of the alternatives, and the availability of equipment and resources to implement the technologies comprising the alternatives.

e. Cost

A net present value of each alternative will be developed. These cost estimates will be used for the relative evaluation of the alternatives, not to bid or budget the work. The estimates will be based on information available at the time of the CMS and on a conceptual design of the alternative. They will be "order-of-magnitude" estimates with a generally expected accuracy of -50 percent to +100 percent for the scope of action described for each alternative. The estimates will be categorized into capital costs and operations and maintenance costs for each alternative.

Section 3.0

3.0 Description of Candidate Corrective Measure Alternatives

3.1 Introduction

Currently available groundwater remedial technologies were screened for applicability to the contaminants and physical conditions present at Combined SWMU 87, with only the most viable technologies known for effective treatment of CVOCs in groundwater selected for alternatives analysis. No source area has been identified, therefore no source control is required. The CVOC exceedances in shallow groundwater are centered around one well, E172GW001, and around well E172GW02D in deep groundwater.

Because all of Zone E will undergo LUCs and the exceedances of screening criteria for arsenic and dieldrin in surface soil are isolated, LUCs will be evaluated as a presumptive remedy for surface soils.

Two presumptive remedies will be considered for site groundwater in the CMS:

- MNA with LUCs, and
- Enhanced In Situ Biodegradation of CVOCs, with LUCs.

The sections below describe each alternative in more detail.

3.2 Alternative 1: Monitored Natural Attenuation with Land Use Controls

3.2.1 Description of Alternative

This alternative will allow the CVOCs to continue to naturally attenuate in the subsurface, will monitor groundwater concentrations periodically until the MCSs are reached, and will impose LUCs (such as a deed restriction) to restrict the installation of drinking water wells.

Natural attenuation is the reduction of CVOC concentrations by the natural processes present in the aquifer, including volatilization, hydrolysis, dilution, dispersion, adsorption, and biotic and abiotic degradation. The collective effort of these processes is termed natural attenuation. MNA is a careful evaluation of natural attenuation mechanisms using monitoring. EPA has issued a Final Office of Solid Waste and Emergency Response

(OSWER) Directive on Monitored Natural Attenuation (EPA, 1999), in which it recognizes that MNA is appropriate as a remedial approach, "where it can be demonstrated capable of achieving a site's remedial objectives within a time frame that is reasonable compared to that offered by other methods, and where it meets the applicable remedy selection criteria for that particular OSWER program." EPA clearly states its expectation that "monitored natural attenuation will be most appropriate when used in conjunction with active remediation measures (e.g., source control) or as a follow-up to active remediation measures that already have been implemented."

The low concentrations of CVOCs in groundwater indicate that a significant source area of contamination is not present. Therefore, no source area treatment technologies are needed at this site.

Concentrations of PCE and TCE are very low, typically below 5 μg/L. The presence of low concentrations of chlorinated solvent daughter products (1,2-DCE and vinyl chloride) demonstrates that degradation of the solvents has occurred. Vinyl chloride has been produced as a result of reductive dechlorination of TCE and 1,2-DCE. 1,2-DCE has been reduced to levels below its MCL. Vinyl chloride typically attenuates under the natural iron-reducing conditions at the site and natural attenuation of vinyl chloride is expected to continue to effectively proceed at the site.

Concentrations of vinyl chloride from the February 2002 sampling event only slightly exceeded the MCL of 2 μg/L, with maximum concentrations of 2.3 μg/L at well E172GW001 and at 4.4 μg/L at DPT sample E172GP002.

Similarly, concentrations of chlorobenzene also do not indicate the presence of a source area of this chemical. Chlorobenzene concentrations in the last two groundwater samples collected from well E172GW001 were below the MCL of 100 μg/L, indicating that the plume is continuing to degrade and naturally attenuate.

Under the natural attenuation alternative, the CVOC plume would be evaluated using a monitoring system designed to track the plume location and concentrations. Monitoring data would be compared to the predicted transport and fate of the CVOCs to check the predictions accuracy. In general, the MNA alternative consists of three major features:

- A designed monitoring program,
- A tracking and data evaluation program, and
- A contingency response plan in the event that the monitoring indicates downgradient migration of dissolved CVOCs.

The MNA alternative would be implemented in conjunction with a long-term monitoring plan. The purpose of the plan is to monitor plume migration over time and to verify that natural attenuation is occurring. The plan would specify existing wells located within, upgradient to, crossgradient to, and downgradient of the plume. Because of the significant amount of data already available for the site, the monitoring plan would focus primarily on monitoring for the CVOCs. Field measurements, such as dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity, would continue to be monitored. Additional parameters, such as ferrous iron, common cations and anions, and dissolved ethene, ethane, and methane, might also be occasionally monitored for, if additional information on these parameters was needed. The data would provide ongoing characterization of plume extent, groundwater quality, hydraulic gradients, ORP indicators, and indicators of biological degradation products of the CVOCs. As shown on the Zone E groundwater potentiometric surface map from 2002 (see Figure 3-1), hydraulic gradients across the site are quite low, and groundwater velocities are expected to be only a few feet per year towards Cooper River.

It is expected that the CVOC plume will slowly decrease in concentration as a result of natural attenuation. Additional contingency remedies would be considered if natural attenuation indicates low performance, as evidenced by increasing trends for total CVOC concentrations at the downgradient edge of the plume that significantly increase potential exposures or related risks. Existing data indicate that this scenario is not likely.

LUCs, such as deed restrictions, would be implemented to restrict the installation of drinking water wells at Combined SWMU 87. Such LUCs could be removed after CVOC concentrations have reduced to MCLs or lower. LUCs are currently planned for Combined SWMU 87, as well as the remainder of the Zone E industrial area.

3.2.2 Key Uncertainties

The uncertainties for the MNA alternative are not significant. Key uncertainties include monitoring well network effectiveness and confirming plume stability (that it is effectively biodegrading and not migrating). The existing monitoring well network is currently generally adequate to delineate groundwater conditions at the site. Continued water level measurements during the routine groundwater quality monitoring events will be utilized to determine if any changes to the monitoring network (such as addition of wells) are required. Uncertainties regarding plume stability will be determined during the continued monitoring of the plume and during demonstration that contamination is not detected in the downgradient wells.

3.2.3 Other Considerations

LUCs restricting the use of groundwater at the site will be necessary during the MNA period until MCLs are achieved. The LUCs will also address the arsenic and dieldrin exposure pathway in surface soils.

3.3 Alternative 2: Enhanced In Situ Biodegradation with Land Use Controls

3.3.1 Description of Alternative

Enhanced in situ biodegradation consists of accelerating the natural biodegradation of organic compounds in groundwater by indigenous microbial populations via introduction of nutrients or other materials into the subsurface. The rate of in situ biodegradation of aerobically degradable chemicals can typically be increased simply by the addition of additional DO into site groundwater, which stimulates rapid population growth of the microbes, resulting in increased destruction rates of contaminants in the groundwater. While it may sometimes be necessary to also increase concentrations of other nutrients (such as phosphorus or other chemicals), many successful enhanced aerobic biodegradation projects have been performed simply by effective addition of DO.

Chlorobenzene, one of the CVOCs at the site, is known to biodegrade under an aerobic pathway. PCE and TCE, the other CVOCs at the site, are known to degrade under anaerobic conditions. Because chlorobenzene has been the COC detected at the highest concentrations in groundwater at this site, an aerobic biodegradation approach was evaluated as an alternative approach.

For aerobic in situ biodegradation of chlorobenzene, the rate-limiting factor is likely the concentration of DO in groundwater. DO concentrations in groundwater can be increased by a variety of technologies, including air sparging, placement of oxygen release compounds (ORCs) in the subsurface or in wells, or other methods. In order to estimate representative costs for implementing an enhanced in situ biodegradation process based on an aerobic biodegradation pathway for the COCs, a DO delivery technology was selected as a basis for a conceptual approach.

The selected DO delivery method is one that delivers high levels of DO to the groundwater via electrolytic cells placed in the wells. This process, referred to as Iso-Gen™ Technology, was developed by EnvironmentalH2O, Inc. The Iso-Gen system also includes a recirculation pump that pulls water from the aquifer into the well, forces it through the electrolytic cell, then back into the aquifer through the well screen. The electrolytic cell dissociates site water into hydrogen and oxygen. The hydrogen off-gas generated in the process is treated by a Raney nickel filter cap placed at the top of the well casing, and the oxygen generated goes into solution in the groundwater. A remote master controller unit converts alternating current (AC) to direct current (DC), which is used to power the pumps and electrolytic cells.

The system can be utilized in existing monitoring wells of 2 inches or greater in diameter. Iso-Gen uses no chemical additives, does not generate any water discharge at the surface, has minimal site impacts, requires no treatment area footprint, and has minimal operating costs.

3.3.2 Conceptual Approach to Implementing Enhanced In Situ Biodegradation

The conceptual approach for implementing this corrective measure approach would be to install an Iso-Gen electrolytic DO generating unit in each of two new wells in the vicinity of E172GW001 and E172GW002. The units would be controlled by a single controller.

According to the manufacturer's information, the approximate radius of DO influence from each downhole unit is up to twice the well screen length. Thus, for shallow wells that are approximately 18 feet deep with 10 feet of well screen, the expected radius of influence would be approximately 20 feet or 40 feet in diameter. Two wells properly located could have a total diameter of influence of up to 80 feet. The units operate on standard 120 volt power and each unit consumes approximately 200 watts. Operation is relatively simple, requiring periodic monitoring and assessment of the DO level in the vicinity of the units.

Other than the installation of the Iso-Gen units, little additional effort is expected to be needed for biodegradation to occur. Because the plume has not exhibited any significant migration from the site, it is likely that some biodegradation is currently occurring and that acclimated indigenous microorganisms capable of degrading the COCs are present in adequate numbers. By providing additional DO, the rate of biodegradation of the plume is expected to increase significantly.

3.3.3 Key Uncertainties

Enhanced biodegradation depends on the availability of the appropriate microbes in situ and in sufficient quantities to respond to the introduction of nutrients at the treatment location. Monitoring the site after implementation of the DO delivery system would provide data to determine whether additional or other nutrients were necessary. The radius of influence of the Iso-Gen system also depends on site-specific aquifer characteristics and hydraulic gradients, well characteristics, and horizontal well spacing. Monitoring the extent of DO influence around the wells would confirm the extent of the radius of influence.

3.3.4 Other Considerations

Water quality in the aquifer may impact the effectiveness of the Iso-Gen system. If conditions are not favorable, scaling and corrosion of the electrolytic cell, pump, and screen can occur, resulting in downtime and increased operating costs. Water quality samples can be collected from existing monitoring wells to verify that site conditions are suitable for the application of the Iso-Gen system.

One additional problem that could potentially occur is plugging of the well screens due to excessive biological growth. The wells in which the Iso-Gen units are located may require periodic cleaning and redevelopment to allow for optimal performance.

Periodic groundwater monitoring will also be required as part of the implementation of the Iso-Gen system alternative, and LUCs will be required to prevent exposure to groundwater until the MCS is met.

NOTE: Original figure created in color

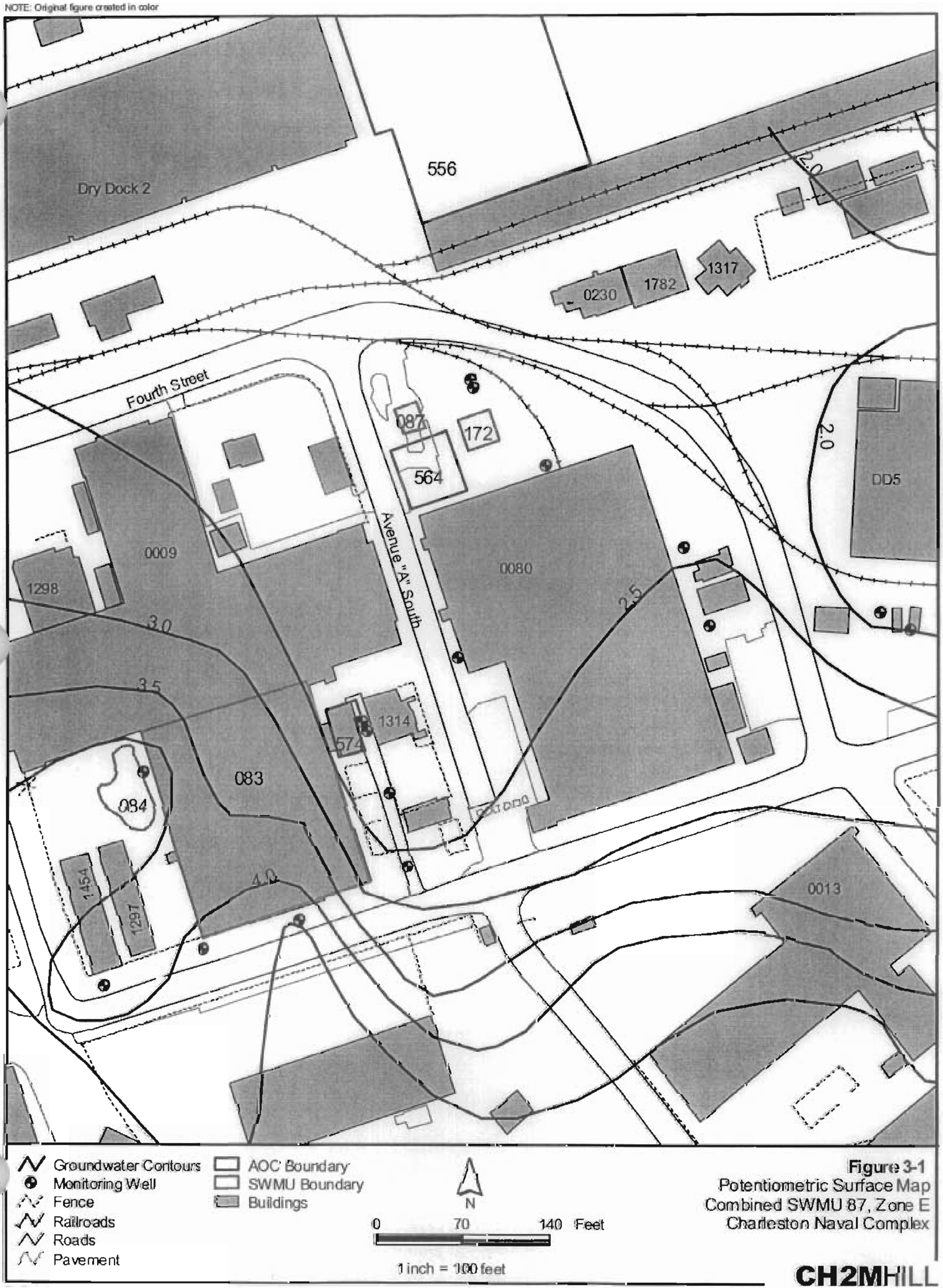

Figure 3-1
Potentiometric Surface Map
Combined SWMU 87, Zone E
Charleston Naval Complex

CH2MHILL

Section 4.0

4.0 Evaluation and Comparison of Corrective Measure Alternatives

The two corrective measure alternatives were evaluated relative to the evaluative criteria previously described in Section 2.0, and then subjected to a comparative evaluation. A cost estimate for each alternative was also developed; the assumptions and unit costs used for these estimates are included in Appendix B.

4.1 Alternative 1: Monitored Natural Attenuation with Land Use Controls

The assumptions for Alternative 1 include the following:

- A base-wide land use control management plan (LUCMP) will be developed for the CNC. The plan will allow for restrictions on the use of groundwater at Combined SWMU 87 and other areas, and will be developed outside the scope of this CMS.
- Periodic groundwater monitoring will be performed until results indicate that the natural attenuation is considered complete and CVOC concentrations are below MCLs, estimated at no more than 5 years at this site. Samples will be collected from the three existing monitoring wells and up to three new monitoring wells on an annual basis, and the samples will be analyzed for CVOCs. Selected MNA parameters will be analyzed, as needed, in the groundwater samples. Standard field parameters (DO, ORP, turbidity, temperature) will be monitored in all wells. For cost estimating purposes, monitoring will be planned for a 5-year period.

4.1.1 Protection of Human Health and the Environment

Alternative 1 is effective at protecting human health because it uses LUCs to prevent the ingestion of, and direct contact with, groundwater.

4.1.2 Attain MCS

Alternative 1 is expected to eventually attain the MCS.

4.1.3 Control the Source of Releases

There are no ongoing sources of releases at Combined SWMU 87.

4.1.4 Compliance with Applicable Standards for the Management of Generated Wastes

Alternative 1 does not generate any wastes that require special management. The primary generated waste would be purge water from monitoring wells, which is easily managed to applicable standards.

4.1.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative 1 has adequate long-term reliability and effectiveness. However, if monitoring well sampling results indicated that unexpected migration of the groundwater plume had occurred, additional corrective measures would likely be necessary.

4.1.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative 1 relies on natural attenuation to reduce the toxicity, mobility, and volume of the contaminated groundwater.

4.1.7 Other Factors (c) Short-term Effectiveness

Through the implementation of LUCs, Alternative 1 has short-term effectiveness in preventing ingestion of, or contact with, the contaminated groundwater. No significant short-term risks would be created using this alternative.

4.1.8 Other Factors (d) Implementability

Alternative 1 is easily implemented since it requires only the implementation of LUCs and an appropriate monitoring well program.

4.1.9 Other Factors (e) Cost

Alternative 1 is the least costly to implement since it requires no construction of treatment facilities or disposal of wastes. The significant component of cost for this alternative is for groundwater monitoring.

Using the assumptions described earlier, the total present value of this alternative is $28,000.

4.2 Alternative 2: Enhanced In Situ Biodegradation with LUCs

A presumptive approach of using a technology such as EnvironmentalH2O's Iso-Gen™ process to deliver additional DO to the aquifer was assumed for evaluating this alternative. The following additional assumptions were made:

- A basewide LUCMP will be developed for the CNC. The plan will allow for restrictions on the use of groundwater at Combined SWMU 87 and other areas, and will be developed outside the scope of this CMS.
- Two new wells would be installed and used to deliver additional DO to the aquifer to stimulate in situ biodegradation. Operation of the DO delivery system and groundwater monitoring would be performed for a duration of 7 years. Samples will be collected from up to six groundwater wells on an annual basis, and will be analyzed for COCs. Selected MNA parameters will be analyzed as needed in the groundwater samples. Standard field parameters (DO, ORP, turbidity, temperature) will also be monitored.

4.2.1 Protection of Human Health and the Environment

Alternative 2 is effective at protecting human health and the environment because it uses LUCs to prevent the ingestion of and direct contact with groundwater during the time period when groundwater CVOC concentrations are greater than the MCS.

4.2.2 Attain MCS

Alternative 2 is expected to achieve the MCS. Because all CVOCs are already typically below the MCL, it is difficult to determine precisely how long it would be necessary to operate the system.. For the purpose of this CMS, it is assumed that the system would attain the MCSs within the range of 3 years.

4.2.3 Control the Source of Releases

There are no ongoing sources of releases at Combined SWMU 87, therefore this issue is not applicable.

4.2.4 Compliance with Applicable Standards for the Management of Generated Wastes

Alternative 2 does not generate any wastes that require special management.

4.2.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative 2 has long-term reliability because of the implementation of LUCs and permanent biodegradation of the COCs.

4.2.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative 2 reduces the toxicity, mobility, and volume of the contaminated groundwater via biodegradation.

4.2.7 Other Factors (c) Short-term Effectiveness

Because of the implementation of LUCs, this alternative will have short-term effectiveness in preventing ingestion of or contact with the contaminated groundwater. No unmanageable hazards would be created during its implementation.

4.2.8 Other Factors (d) Implementability

This alternative is relatively easily implemented

4.2.9 Other Factors (e) Cost

Appendix B presents the overall cost estimate for implementing this remedy. The total present value of Alternative 2 is $132,000.

4.3 Comparative Evaluation of Corrective Measure Alternatives

Each corrective measure alternative's overall ability to meet the evaluation criteria is described above. In Table 4-1, a comparative evaluation of the degree to which each alternative meets a particular criteria is presented.

TABLE 4-1
Comparative Evaluation of Corrective Measure Alternatives
Corrective Measures Study Report, Combined SWMU 87, Zone E, Charleston Naval Complex

Criterion	Alternative 1 Monitored Natural Attenuation with LUCs	Alternative 2 In Situ Enhanced Biodegradation with LUCS
Overall Protection of Human Health and the Environment	Adequately protects human health and the environment	Adequately protects human health and the environment
Attainment of MCS	Expected to attain MCSs within 5 years	Expected to attain MCSs within 3 years
Control of the Source of Releases	No sources present at this site	No sources present at this site
Compliance with Applicable Standards for the Management of Wastes	Can be implemented to comply with applicable standards	Can be implemented to comply with applicable standards
Long-term Reliability and Effectiveness	Expected to be reliable and effective in the long term	Expected to be reliable and effective in the long term
Reduction of Toxicity, Mobility, or Volume through Treatment	Reduces toxicity, mobility, and volume via biodegradation	Reduces toxicity, mobility, and volume via biodegradation
Short-term Effectiveness	Effective in short term via LUCs	Effective in short term via LUCs
Implementability	Very easily implemented	Moderately easy to implement
Estimated Cost (in $1,000)	$28,000	$132,000

Section 5.0

5.0 Recommended Corrective Measure Alternative

Two corrective measure alternatives were evaluated for groundwater COCs using the criteria described in Section 2.0 of this CMS report: Alternative 1: Monitored Natural Attenuation with LUCs, and Alternative 2: In Situ Enhanced Biodegradation with LUCs.

The RAOs identified for groundwater at Combined SWMU 87 are: 1) to prevent ingestion and direct/dermal contact with groundwater or surface soil having unacceptable carcinogenic or noncarcinogenic risk; 2) to prevent migration to offsite areas; and 3) to restore the aquifer to beneficial use.

Based on the alternatives evaluation and RAOs for the site and current uncertainties associated with each alternative, the preferred corrective measure alternative is Alternative 1: Monitored Natural Attenuation with LUCs. Alternative 1 would provide protection of human health and the environment by maintaining the current and planned future use of the site as industrial while the contaminants naturally degrade to non-toxic end products. Limitations would prevent residential and other unrestricted land use, including installation of water supply wells, that could expose sensitive populations.

An LUCMP is being developed for the industrial areas of the CNC, and Combined SWMU 87 will be added to the plan. The LUCMP will limit future site activities to those that would limit exposure to groundwater. Current data indicate that the contaminants are not migrating, likely due to in situ natural biodegradation, and are expected to continue to do so. The expected reliability of this alternative is good. Should monitoring data indicate that this alternative is not as effective as expected, additional measures could be safely implemented.

Section 6.0

6.0 References

CH2M-Jones. *RFI Report Addendum and CMS Work Plan, Combined SWMU 87, Zone E, Charleston Naval Complex*. Revision 0. November 2001.

EnSafe Inc. *Zone E RFI Report, NAVBASE Charleston, Revision 0*. November 1997.

EnSafe Inc./Allen & Hoshall. *Zone E RFI Report Workplan*. 1995.

South Carolina Department of Health and Environmental Control (SCDHEC). RCRA Permit SC0 170 022 560. Charleston Naval Complex, Charleston, South Carolina. August 17, 1988.

U.S. Environmental Protection Agency (EPA). Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Office of Solid Waste and Emergency Response (OSWER) Final Directive 9200.4-17P. 1999.

Appendix A

NOTE: Original figure created in color

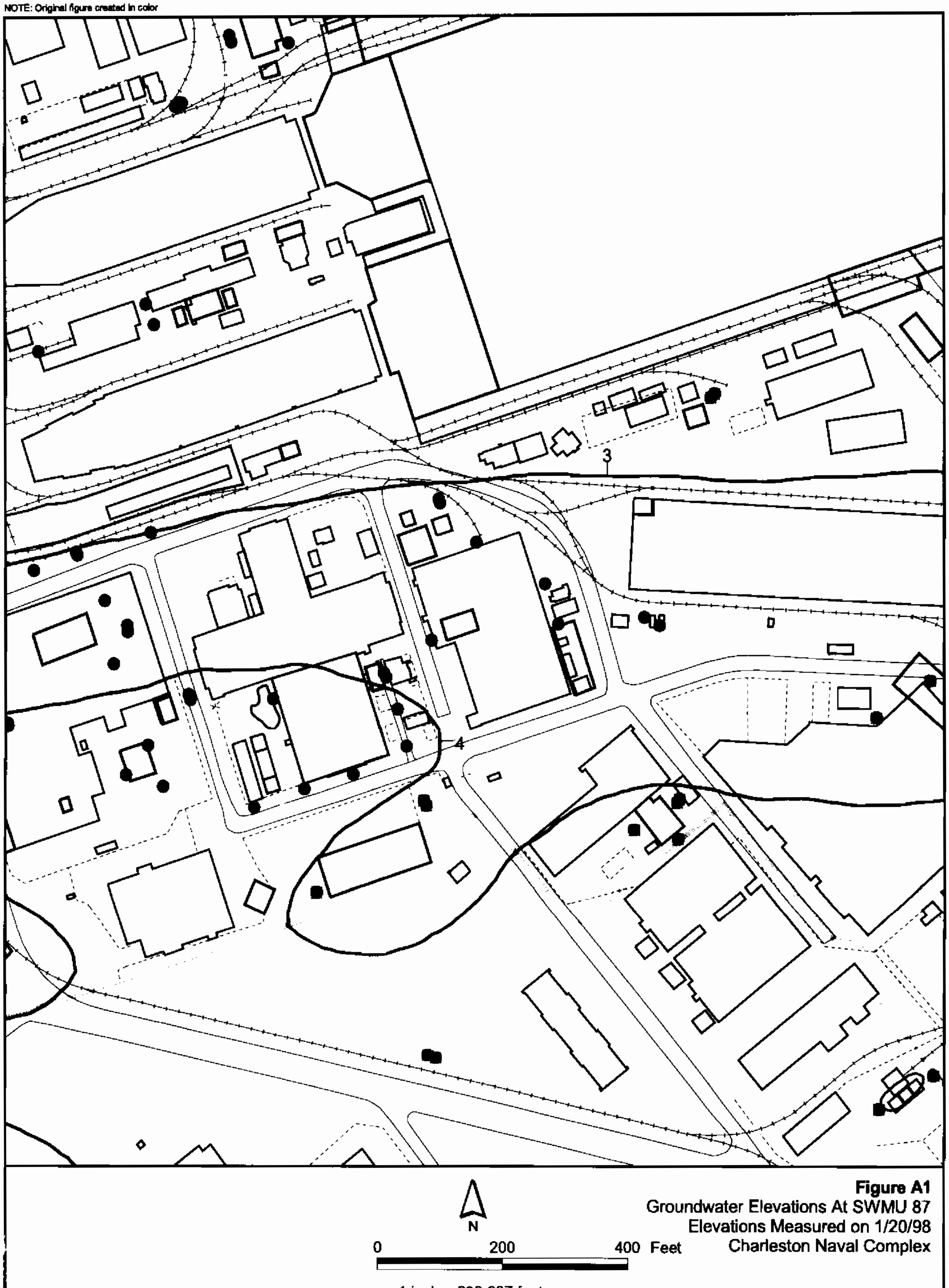

Figure A1
Groundwater Elevations At SWMU 87
Elevations Measured on 1/20/98
Charleston Naval Complex

File Path: c:\18gis\cnc\cnc-egis.apr, Date: 28 Aug 2003 9:38, User: DWILLIAM, EGIS: Charleston Naval Complex - Figure A1 Groundwater Elevations At SWMU 87

Appendix B

COMPARISON OF TOTAL COST OF REMEDIAL SOLUTIONS

Site: Charleston Naval Complex
Location: SWMU 87
Phase: Corrective Measures Study
Base Year: 2003
Date: 08/15/03

	Alternative Number 1 **Monitoring/ Natural Attenuation**	Alternative Number 2 **In-Situ Bio Sparging**
Total Assumed Project Duration (Years)	5	3
Capital Cost/O&M Cost	$6,400	$119,000
Annual Monitoring Cost	$4,700	$4,700
Total Present Worth of Solution	$28,000	$132,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order-of-magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.

Element: Sample Collection and Laboratory Costs
Alternative: 1, 2

Site:	Charleston Naval Complex	**Prepared By:** DFW	**Checked By:**
Location:	SWMU 87	**Date:** 08/15/03	**Date:**
Phase:	Corrective Measures study		
Base Year:	2003		

WORK STATEMENT

Costs associated with water sample collection, shipment and analysis on a per event basis; no natural attenuation parameters.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Equipment & Labor per Event					STL estimate
Sample Analysis (VOCs - EPA 8260 - Level II)	3	SAMPLE	$110	$330	2 Wells,1 extra QA/QC samples
Sampling Supplies	1	EA	$200	$200	
Groundwater Sampling Equipment Rental	0.2	WK	$600	$120	Includes MultiRAE and Peristaltic Pump
Sample Shipment	1	EA	$200	$200	CH2M-Jones Estimate
Labor - Technicians	8	HR	$55	$440	3 hrs/well, 2 people, includes data validation
SUBTOTAL				$1,290	
Project Management	2%	of	$1,290	$26	
Technical Support	2%	of	$1,290	$26	
Construction Management	0%	of	$1,290	$0	
Subcontractor General Requirements	0%	of	$1,290	$0	
SUBTOTAL				$1,342	
TOTAL UNIT COST				$1,300	

OPERATION AND MAINTENANCE COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
SUBTOTAL				$0	
Contingency	20%		$0	$0	
SUBTOTAL				$0	
TOTAL O&M COST				$0	

Source of Cost Data

1. Analytical Bid Form - Charleston Naval Complex - Level III

Alternative 1: Monitoring/Natural Attenuation

COST ESTIMATE SUMMARY

Site: Charleston Naval Complex
Location: SWMU 87
Phase: Corrective Measures Study
Base Year: 2002
Date: 08/15/03

Description:
Monitoring/natural attenuation of the surficial aquifer.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
Monitoring/Natural Attenuation Work Plan				
Groundwater Contingency Plan				
Labor - Project Manager	6	HR	$125	$750
Labor - Engineer/Hydrogeologist	24	HR	$90	$2,160
Labor - Editor	8	HR	$65	$520
Labor - CAD Technician	4	HR	$65	$260
Initial Groundwater Sample Collection	1	EA	$1,342	$1,342
SUBTOTAL				**$5,032**
Project Management	5%	of	$5,032	$252
Technical Support	5%	of	$5,032	$252
SUBTOTAL				**$5,535**
Contingency	15%	of	$5,535	$830
TOTAL CAPITAL COST				**$6,400**

OPERATIONS AND MAINTENANCE COST

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
yrs 1 - 15	Annual Groundwater Sample Collection	1	EA	$1,342	**$1,342**
	Annual Report				
	Labor - Project Manager	6	HR	$125	$750
	Labor - Engineer/Hydrogeologist	16	HR	$90	$1,440
	Labor - Editor	6	HR	$65	$390
	Labor - CAD Technician	12	HR	$65	$780
	SUBTOTAL				**$3,360**
yrs 1 - 15	**TOTAL ANNUAL O&M COST**				**$4,700**

PRESENT VALUE ANALYSIS

Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	COST PER YEAR	TOTAL PRESENT WORTH
1	FIRST YEAR CAPITAL COST	$6,400	$6,400	$6,400
1 - 5	ANNUAL O&M COST (Year 1 - 5)	$23,500	$4,700	$21,402
				$27,802
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$28,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative 2: **Enhanced In Situ Biodegradation** **COST ESTIMATE SUMMARY**

Site: Charleston Naval Complex
Location: SWMU 87
Phase: Corrective Measures Study
Base Year: 2003
Date: 08/15/03

Description: Use Iso-Gen system to increase Do in groundwater

CAPITAL COSTS AND ISOGEN SYSTEM OPERATION

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
Install/operate Isogen System for 3 years	1	EA	$110,000	$110,000
SUBTOTAL				**$110,000**
Baseline Groundwater Sample Collection	1	EA	$1,342	$1,342
Groundwater Sample during pilot test	2	EA	$1,342	$2,683
SUBTOTAL				**$4,025**
Summary Report				
Labor - Project Manager	16	HR	$125	$2,000
Labor - Engineer/Hydrogeologist	24	HR	$90	$2,160
Labor - Editor	8	HR	$65	$520
Labor - CAD Technician	12	HR	$65	$780
SUBTOTAL				**$5,460**
TOTAL CAPITAL COST				**$119,000**

OPERATIONS AND MAINTENANCE COST - Monitoring

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
yrs 1 - 2	annual Groundwater Sample Collection	1	EA	$1,342	**$1,342**
	Annual Report				
	Labor - Project Manager	6	HR	$125	$750
	Labor - Engineer/Hydrogeologist	16	HR	$90	$1,440
	Labor - Editor	6	HR	$65	$390
	Labor - CAD Technician	12	HR	$65	$780
	SUBTOTAL - Annual Report				**$3,360**
yrs 1 - 3	**TOTAL ANNUAL O&M COST**				**$4,700**

PRESENT VALUE ANALYSIS

Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT VALUE
1 - 3	CAPITAL COST AND 7 YEAR ISOGEN Operations	$119,000	$119,000	$119,000
1 - 3	ANNUAL Monitoring Costs (Year 1 - 3)	$9,400	$4,700	$13,244
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$132,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

COST ESTIMATE SUMMARY - INSTALL ISOGEN SYSTEM/ 7 YEARS O&M

Site:	SWMU 87	**Prepared By:**	DFW
Location:	Charleston Naval Complex	**Date:**	
Phase:	CMS		
Base Year:	2003		
Date:	15-Aug-03		

CAPITAL COST and 7 Year Operating Costs for Isogen Units

DESCRIPTION	QTY	UNIT	COST	TOTAL	NOTES
SUBCONTRACTOR SERVICES					
New Well Installation	2	wells	$3,500	$7,000	
Iso-Gen Units; 1 controller, 2 units	1	unit	$8,000	$8,000	
Two Man Construction Crew	6	days	$750	$4,500	
Sawcut, Trenching, Backfill, Disposal	80	LF	$45	$3,600	
Piping and Misc Materials	1	LS	$1,500	$1,500	
Site Restoration	1	LS	$1,200	$1,200	
Mobilization/Demobilzation	1	LS	$1,000	$5,000	
System Start-Up	1	LS	$1,500	$3,000	
Electrical (Power Drop and Installation)	1	LS	$1,500	$1,500	
SUBTOTAL				$35,300	
PROFESSIONAL SERVICES DURING CONSTRUCTION					
Project Management	24	hr	$ 128	$3,068	
Work Plan, UIC Permit, Reporting (Engr)	60	hr	$ 95	$5,721	
Installation Oversight (Tech)	40	hr	$ 59	$2,353	
Start-Up (Tech)	32	hr	$ 59	$1,882	
Per-Diem/Misc	5	LS	$ 750	$3,750	
SUBTOTAL				$16,774	
TOTAL CAPITAL COST				**$52,074**	

OPERATIONS COST (3 YEARS)

DESCRIPTION	QTY	UNIT	COST	TOTAL	NOTES
CONSUMEABLES					
Electrical Usage (estimated)	8000	kW-hr	$0.07	$560	Engineers estimate
SUBTOTAL				$560	
MISC SERVICES					
Misc Iso Gen Support	1	LS	$ 3,000	$3,000	
Equipment Rental	3	yr	$500	$1,500	$500/yr
Operation and Maintenance	360	hr	$60	$21,600	10 hours/mo
Contingency Mechnical Repairs	1	LS	$4,000	$4,000	Engineers estimate
SUBTOTAL				$30,100	
PROFESSIONAL SERVICES					
Project Management	72	hr	$ 128	$9,204	2 hrs/mo
Operations - Engineering Support	72	hr	$ 95	$6,865	2 hrs/mo
Per-Diem/Misc	1	ls	$ 750	$750	Engineer's estimate
SUBTOTAL				$16,820	
TOTAL OPERATIONS COST				**$47,480**	
TOTAL COST W/ 10% CONTINGENCY				**$110,000**	

Notes:

1. Add sampling costs after first 3 months

Element: **Present Worth Analysis**
Alternative: **Monitoring/Natural Attenuation**

Site: Charleston Naval Complex
Location: SWMU 87
Phase: Corrective Measures Study
Base Year: 2003

Prepared By: DFW
Date: 08/15/03

Checked By:
Date:

WORK STATEMENT

Calculation of alternative present worth. Assumes total present value earns interest for an entire year (12 months), compound annually.

Discount Rate 3.2%

Present Worth Analysis

Elapsed Time	Year	Discount Factor at 3.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 3.2%	Total PV O&M Costs at 3.2%	Total PV Costs at 3.2%	Balance of Interest Bearing Account at 3.2%
0	2003	1.000	$ 6,400		$ 6,400	$ 6,400	$ -	$ 6,400	$ 22,087
1	2004	0.969		$ 4,700	$ 4,700	$ -	$ 4,554	$ 4,554	$ 17,944
2	2005	0.939		$ 4,700	$ 4,700	$ -	$ 4,413	$ 4,413	$ 13,667
3	2006	0.910		$ 4,700	$ 4,700	$ -	$ 4,276	$ 4,276	$ 9,254
4	2007	0.882		$ 4,700	$ 4,700	$ -	$ 4,144	$ 4,144	$ 4,700
5	2008	0.854		$ 4,700	$ 4,700	$ -	$ 4,015	$ 4,015	$ 0
6	2009	0.828		$ -	$ -	$ -	$ -	$ -	$ 0
7	2010	0.802		$ -	$ -	$ -	$ -	$ -	$ 0
8	2011	0.777		$ -	$ -	$ -	$ -	$ -	$ 0
9	2012	0.753		$ -	$ -	$ -	$ -	$ -	$ 0
10	2013	0.730		$ -	$ -	$ -	$ -	$ -	$ 0
11	2014	0.707		$ -	$ -	$ -	$ -	$ -	$ 0
12	2015	0.685		$ -	$ -	$ -	$ -	$ -	$ 0
13	2016	0.664		$ -	$ -	$ -	$ -	$ -	$ 0
14	2017	0.643		$ -	$ -	$ -	$ -	$ -	$ 0
15	2018	0.623		$ -	$ -	$ -	$ -	$ -	$ 0
Total Alternative			$ 6,400	$ 23,500	$ 29,900	$ 6,400	$ 21,402	$ 27,802	

Element: **Present Worth Analysis**
Alternative: **In-Situ Bio-Sparging**

Site: Charleston Naval Complex
Location: SWMU 87
Phase: Corrective Measures Study
Base Year: 2003

Prepared By: DFW
Date: 08/15/03

Checked By:
Date:

WORK STATEMENT

Calculation of alternative present worth. Assumes total present value earns interest for an entire year (12 months), compound annually.

Discount Rate 3.2%

Present Worth Analysis

Elapsed Time	Year	Discount Factor at 3.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 3.2%	Total PV O&M Costs at 3.2%	Total PV Costs at 3.2%	Balance of Interest Bearing Account at 3.2%
0	2003	1.000	$ 119,000		$ 119,000	$ 119,000	$ -	$ 119,000	$ 13,667
1	2004	0.969		$ 4,700	$ 4,700	$ -	$ 4,554	$ 4,554	$ 9,254
2	2005	0.939		$ 4,700	$ 4,700	$ -	$ 4,413	$ 4,413	$ 4,700
3	2006	0.910		$ 4,700	$ 4,700	$ -	$ 4,276	$ 4,276	$ (0)
4	2007	0.882		$ -	$ -	$ -	$ -	$ -	$ (0)
5	2008	0.854		$ -	$ -	$ -	$ -	$ -	$ (0)
6	2009	0.828		$ -	$ -	$ -	$ -	$ -	$ (0)
7	2010	0.802		$ -	$ -	$ -	$ -	$ -	$ (0)
Total Alternative			**$ 119,000**	**$ 14,100**	**$ 133,100**	**$ 119,000**	**$ 13,244**	**$ 132,244**	